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Notes on the Visit of Fabio Sauli

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On June 28 and 29, we had a visit by the noted chamber builder, Fabio Sauli. He gave a seminar on recent developments in high-rate, high-resolution gaseous detectors. Of equal importance to us, he participated in a three hour discussion with members of Hall B in which we raised a variety of questions. We then showed him the large prototype chamber while it was being strung, and he asked us a number of questions concerning our design. The purpose of this memo is to record the various comments and questions which he raised during his visit.

Multi-Drift Module and Microstrip Chamber

Professor Sauli started his visit here by giving a seminar on two recent designs which he and his colleagues have been working on: the multi-drift module and the microstrip chamber. The multi-drift module is a box, hexagonal in shape, which contains many wires arranged in an hexagonal pattern (oriented at 90° compared to ours in order to minimize cross-talk). The cells have maximum drift distances of $1.4mm$ and the sense and field wires are $30\mu m$ stainless steel and $80\mu m$ Cu-Be, respectively. An important consideration is to have a smooth surface on the cathode wires; he advocates keeping the surface electric field below $40kV/cm$.

The chamber is built for high rate capability; hence the small cells. It is able to handle $3 \cdot 10^5$ particles per cm^2s. The resolutions achieved have been $50\mu m$ perpendicular to the wire and $3mm$ along the wire, using charge division. The preamplifiers are made by Fujitsu, and the sense wire holes are drilled with $20\mu m$ placement accuracy. To decrease the resolution smearing due to the distance between primary ionization clusters, DME was used as the chamber gas. It is a dense gas with low Z atoms. It gives about 55 ion pairs/cm, with the average spacing between ions being $150\mu m$. It also has a low diffusion characteristic, and because it's a good quencher allows high gains up to 10^6. The discriminator threshold was set to about $1/20^{th}$ of the average pulse height in order to be sensitive to the arrival of the first drifting electron.

The microstrip gas chamber consists of metal strips laid down on glass. These strips constitute the anode and cathodes (there is an additional cathode plane, also). It has been able to provide good energy and spatial resolution. In their design, the anodes are 5 to 10 μm wide and the cathodes are 30 to 60 μm wide. Anode to cathode spacings are typically 100 μm. The distance to the cathode plane is typically 3 mm.

General Discussion about our Drift Chamber

Maximum electric field at cathode wire surface - he said that the ratio of anode to cathode radii is appromately independent of the gas mixture used; e.g. a highly quenching gas would need higher voltages and higher surface fields but field emission breakdown is less serious. He has run a chamber with a surface cathode field of $70kV/cm$; using DME gas and 30 and 100 μm anode and cathode wires. It's important to use good quality wire. He doesn't like 20 μm wire because of handling difficulties and because gas gain saturation is worse than for larger anode wires, and larger diameter wire has better uniformity of gain. He also warns that gold-plated wire often has poor surface quality. He suggested a test for wire quality: make a tube proportional counter and run the wire as the cathode and determine voltage at which breakdown occurs.

High voltage - need fine segmentation. Be careful of too much capacitance in high voltage system; 5 kV and 500 pF will break 20 μm wire. We should consider fuses on high voltage wires; possibly small wire from power supply to high voltage wire.

Long drift distances - these are a concern because electrons can be captured by oxygen or other impurities if the drift time is too long; for example, through a low field region. This is another advantage of thicker wires; for a given gain the field is higher and so is the drift velocity.

Lasers for drift chamber calibration - he recommends a permanently installed laser calibration system. Fred Harges is building the lasers for one of the LEP detectors; these are dual cavity nitrogen lasers which have low dispersion.

Additives to gas - don't use additives if the rates are less than 0.1 C/cm and the conditions are clean; can't use alcohol in a recirculating system.

Gas mixture - Methane is definitely an option; it's not quite as good a quencher as Ethane but it's easier to purify and less polymerizing. A 92/8% mixture of Argon and Methane is non-flammable. He/Methane is good but will probably not be very good for energy loss measurements. As an aside, Landau fluctuations for hydrocarbons are smaller than for Argon; thus you want a rich hdrocarbon mixture for dE/dx. Nitrogen is not easily removed; it will build up in a recirculating system. Its removal involves heating the gas. To check for leaks in the chamber - seal it up and measure the pulse height as a function of time using an X-ray source. The pulse height will deteriorate as oxygen leaks in.

Mini-stagger - he voiced concern that the asymmetry of the cell would cause the gain to vary from one side of the wire to the other.

Conclusions

We are pursuing many of the suggestions which Professor Sauli made:

1) wire diameters - lessening the criteria that the surface field at the cathode wire be less than 20 kV/cm would allow us to use thinner cathode wires; possibly even Cu-Be wire. We are looking into this.

2) wire quality test chamber - we will build a small tube counter with a wire along the axis and run it with the wire as cathode to study breakdown conditions. This should be a good indicator of wire quality.

3) high voltage - our high voltage and readout translator boards will be designed to eliminate wire breakage due to excessive capacitance, and thus excessive stored energy.

4) laser calibration system - we are looking for collaborators who might be interested in developing a laser calibration system for the drift chambers which would be a source of straight tracks through the actual chambers.

5) gas system - we are investigating alternative gas mixtures, including ones with Methane or Helium. The main message: keep things clean!